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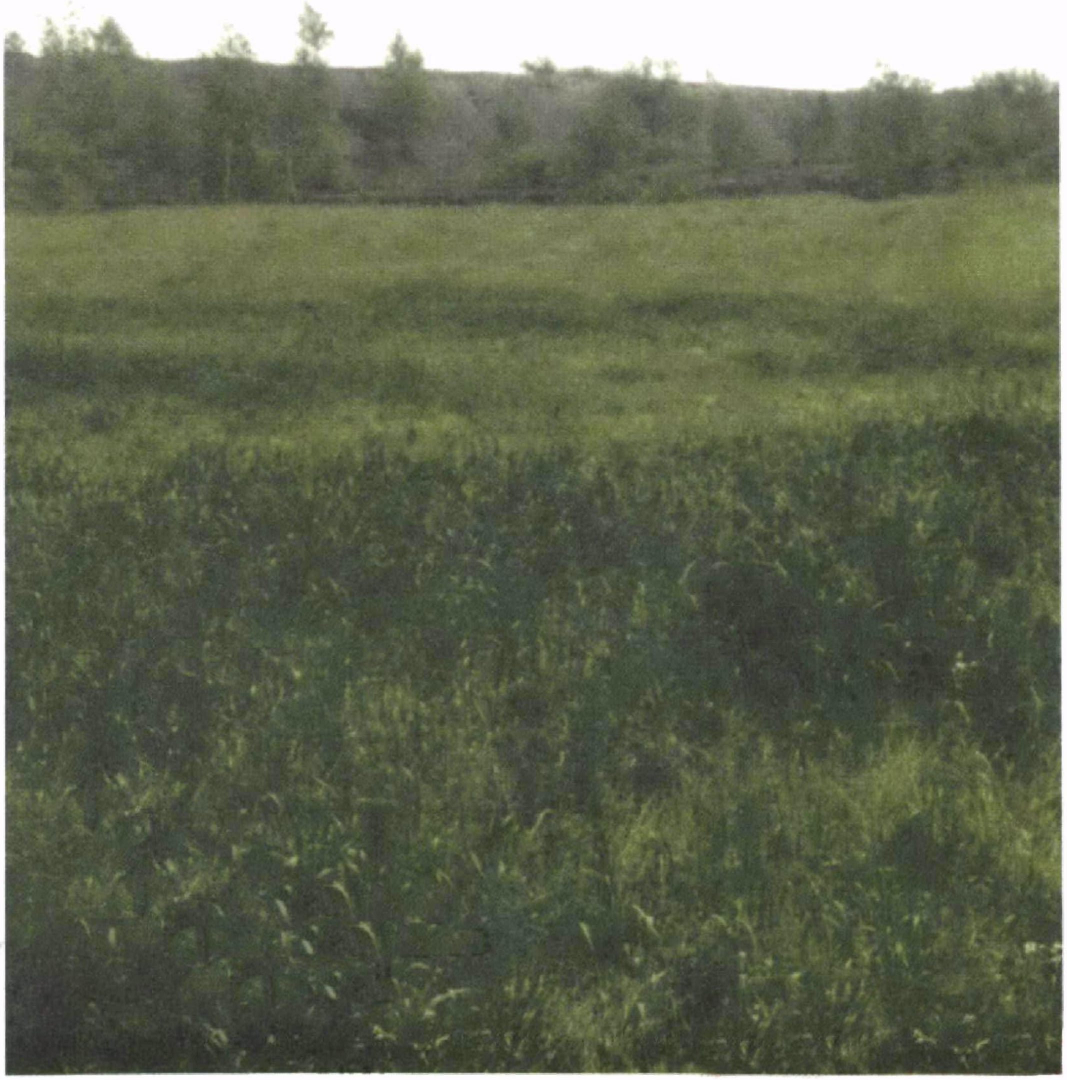
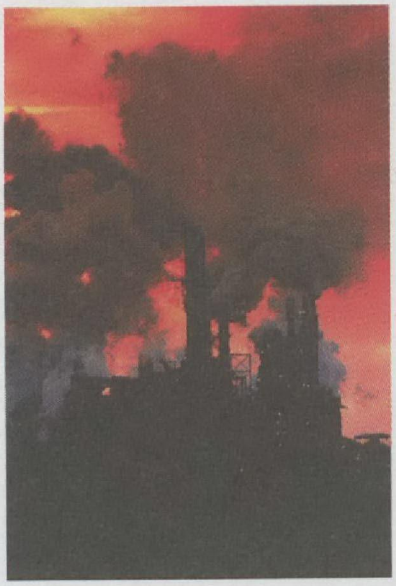
Poland Biosolids Smelter Waste Reclamation Project



This brochure describes the background, methodology, results, and benefits of a unique biosolids remediation project that occurred in Poland from 1994 through 1999. The project was sponsored and coordinated by the U.S. Agency for International Development and the U.S. Environmental Protection Agency. By applying a mixture of biosolids and waste lime to some highly toxic smelter and coal waste piles, the project developed an inexpensive technique to revegetate previously barren land. The vegetation now greatly reduces the amount of contaminated runoff and dust from these piles, which was a major health risk in the area.

Background and Problem Identification

The Upper Silesia region, where this project took place, is located in southwestern Poland. The city of Katowice is the political center of the region, which encompasses 14 cities, and is home to over three million people. The region is rich in coal, zinc, lead, and other metals. This has made it an ideal center for the country's heavy industry and mining. However, this industrial activity has taken its toll on the local environment. In communist times the environment was sacrificed for economic gain. Waterways were too toxic for any aquatic life, and the sky was often darkened by stack emissions.



Massive smelter and coal waste piles dot the landscape of Upper Silesia. Over 96 million tons of mining wastes were deposited in the area over the last century. It is estimated that over 90% of the solid waste material produced by the heavy industry and mining sector in Poland has been deposited on the 2% of Poland that is encompassed by the Upper Silesia region. In this small area there are several thousand acres of waste piles that require remediation. Most of these piles are barren and are phytotoxic, which prevents revegetation, both natural and artificial. In addition, these piles typically contain high levels of heavy metals, which pose a health risk to the surrounding communities. The waste piles are often located in heavily populated areas, and without any vegetation covering the piles, they are susceptible to water and wind erosion. Dust particles enter the air and are found in high concentrations in the nearby houses and on local soils where produce is grown. Children in the area have shown elevated lead levels in their blood.

Since the fall of Communism in 1989, new laws and regulations have been enacted to protect and restore the environment. Progress has been made with advances such as the installation of stack emission scrubbers and the construction of wastewater treatment plants. However, intense economic and employment pressures have hindered environmental efforts. Any plan for remediating the waste piles would need to be inexpensive.

Orzel Bialy smelter waste pile in 1994, before remediation efforts began.

Past efforts to reclaim similar waste piles in Poland included covering them with topsoil. This approach is extremely expensive, since the topsoil must be excavated and transported from other areas, and was often not effective on the highly contaminated waste piles of Upper Silesia. One potential alternative for reclaiming waste piles involves the use of biosolids (treated sewage sludge) produced by wastewater treatment plants.

The amount of biosolids available in the area has been increasing rapidly. In the past year alone the amount of biosolids produced in Silesia has more than doubled. Over the past ten years about 3,000 wastewater treatment plants have been built in Poland. In 1990, it was estimated that only 60% of the municipal wastewater flows in the country received any treatment. Of these, the majority only received primary treatment. New plants utilizing activated sludge and other more advanced treatment processes are being constructed rapidly. The massive increased volume of biosolids generated by these treatment plants was becoming a serious management problem for the treatment plants. However, it also created a potential opportunity for use in reclaiming waste piles.

Methodology

Between 1994 and 1999 a team of scientists from the United States and Poland worked together to examine the feasibility of utilizing biosolids from local wastewater treatment plants and lime from mine water treatment to revegetate several different types of lead/zinc smelter waste piles. The biosolids study was part of a larger environmental effort named "Project Silesia." Funding was provided by the U.S. Agency for International Development and the project was coordinated by the U.S. Environmental Protection Agency. Although biosolids have been used for remediation of polluted sites in the past, they have never been tested on such highly contaminated sites.

The project team included U.S. scientists from EPA, USDA and Virginia Tech as well as Polish scientists from the Institute of Soil and Plant Cultivation in Pulawy, Poland, and the Center for Research and Control of the Environment in Katowice, Poland. The team based its work in part on previous work involving the use of biosolids at the Palmerton, PA Superfund site. The goal of the project was to provide guidelines for the effective and inexpensive use of biosolids in stabilizing highly contaminated waste piles.

Two sites were chosen comprising smelter wastes from a Doerschel furnace and a Welz smelting process. The site covered a total of 2 hectare, all of which was barren of vegetation. Before installation of the experiment, it was important to assess the exact chemical and structural nature of the waste piles. Samples from over 160 grid points (from 0 -5 and 20 - 25 cm) were collected from a 10 m square and analyzed for pH, potential acidity, electrical conductivity, and for total S, Zn, Cd, and Pb. The Doerschel wastes showed much higher average levels of total and water soluble metals and a lower pH (Table 1).

Orzel Bialy smelter waste site in 1996.

Table 1. Chemical Properties of Waste Samples before (1994) and after (1995) Amendment

Waste	Sampling Time	(Total)/Soluble Zinc (mg/kg)	(Total)/Soluble Cadmium(mg/kg)	(Total)/Soluble Lead (mg/kg)	pH
Welz	Before	(30,900) 343	(540) 17.6	(7,900) 1.8	7.0
	After	279	17.7	1.1	7.2
Doerschel	Before	(75,000) 1,670	(2,310) 108	(23,820) 5.4	5.8
	After	983	57.4	2.9	6.0

Based on these findings, test plots for determining salt/metal tolerant grasses were established in a 90 day greenhouse trial. Nine of the most tolerant grasses were selected for use in the study.

Lime was necessary to suppress mobility and plant uptake of heavy metal ions which would otherwise cause phytotoxicity. It was determined that calcium carbonate alone would not be sufficient to suppress metal mobility, so calcium oxide would also be necessary, particularly on the Doerschel wastes. Calcium oxide is much more efficient at raising pH and reducing metal solubility and mobility, but eventually transforms into calcium carbonate, so it was not clear how this would affect the sites in the long term. The lime used on the sites was a byproduct of mine water treatment.

One half of each site was left as a control. The other halves were graded and treated with an application of biosolids and lime:

- The Welz wastes received 30 Mg/ha (dry tons/ha) of $CaCO_3$ and 1.5 Mg/ha CaO and the Doerschel wastes received 30 Mg/ha of $CaCO_3$ and 15 Mg/ha CaO. Biosolids were applied on top of the lime at 0, 150, and 300 Mg/ha to 1/3 of each test area.

- The lime and biosolid amendments were then incorporated with a chisel plow. Higher biosolid amendments were added in steps, interspersed with plowing, to ensure appropriate incorporation.

- Seeding with the metal- and salt- tolerant grasses occurred in the fall of 1994.

Before treatment and after each growing season a monitoring program was conducted to measure above-ground biomass, metal content in plants, and changes in waste chemical properties, including pH, metal solubility, and salinity.

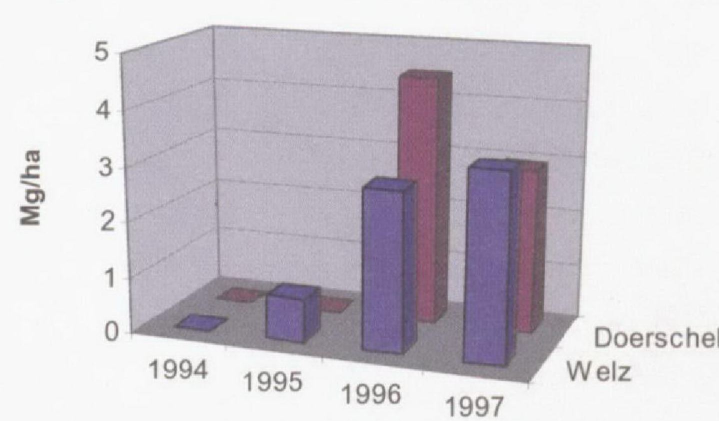
Results

Vegetation was established on 85% of the Welz area in the spring of 1995 despite the high levels of water soluble metals (Table 1). However, vegetation did not establish on the Doerschel area in 1995. This failure was most likely due to the high salinity and high metal toxicity due to the elevated levels of soluble zinc and cadmium. High compaction and cementation of the Doerschel wastes may also have contributed. Calcium carbonate ($CaC0_3$) apparently was not effective in raising pH and reducing metal mobility. Laboratory experiments showed that additional amounts of calcium carbonate had little effect. Calcium oxide (CaO), however, was very effective in raising pH and reducing metal mobility. This effect probably only lasts for the short term, though, since CaO did not have much effect on pH or metal mobility in the field plots after one year.

The Doerschel waste area was retreated in 1995 with a 15 cm cap of lime (CaO + $CaCO_3$) and 300 Mg/ha biosolids. The sludge was incorporated into the top of the lime cap with a chisel plow, and was seeded with same grasses used in 1994. This resulted in 75 to 80% vegetation cover by the spring of 1996 with little evidence of metal toxicity. Figure 1 shows standing biomass yields at the two sites from 1995 through 1997.

Plant roots only penetrated through the first 2 cm of the underlying waste material at the Doerschel site, indicating that on highly toxic sites, the ability of plants to withstand a long summer drought may be diminished. This will be a subject for future study. Plant roots on the Welz wastes, however, penetrated to a depth of 10 to 20 cm, and legumes and native herbaceous and woody species had begun to grow on the site by 1996, supporting the hypothesis that the treatment was effective in providing support for long term plant growth. Heavy metals were present in plant tissues, as would be expected, but were stable over time.

Figure 1. Total Mean Biomass Yield



The results of a feeding study conducted with young cattle to measure the extent of metal

(Pb, Cd and Zn) transfer to meat and organs from hay harvested from the reclamation site indicated that forage grown on the highly contaminated sites reclaimed with lime and biosolids posed no particular risk to cattle.

Benefits and Conclusions

This project was highly successful and can serve as a model for remediating similar sites in the region and around the world including the United States. The project demonstrated that biosolids can be effectively used to help revegetate highly toxic smelter wastes as an alternative to traditional methods such as topsoiling. High concentrations of soluble metals can be effectively reduced by the addition of appropriate forms and doses of lime. Used in combination, biosolids and liming can create conditions suitable for effectively revegetating highly toxic smelter waste with grass species and cultivars selected for their resistence to metal toxicity, while limiting the movement of metals into the terrestrial ecosystem that becomes established on the reclaimed site.

Based on the results, the scientists recommend a one time application of lime and biosolids of 75 to 150 Mg/ha and identified a list of the most acid/salt tolerant grass species and cultivars for use in seeding mixtures. The exact amounts of amendments and seeding mixtures should be based on a

Native woody species can be seen returning to the Orzel Bialy smelter waste site in this 1999 photograph.

detailed survey of the chemical properties of the waste at the site. For heavily contaminated sites, such as the Doerschel site, a lime cap with a high percentage of calcium oxide may be needed, in addition to higher amounts of biosolids (300 Mg/ha), to ensure the effective establishment of vegetation. It will be several years, however, before the group can finalize its application guidelines.

Some of the benefits of this remediation approach are:

- It is relatively inexpensive compared to conventional techniques and it is very effective. Covering smelter waste piles with topsoil requires that soil be removed from land somewhere else, at greater expense and environmental damage.

- Lime can often be acquired inexpensively, as in this case, where it was the byproduct of mine water treatment.

- Compared to using topsoil, the combination of biosolids and lime can achieve a more effective remediation of areas contaminated with heavy metals by reducing metal solubility.

- This approach provides an environmentally safe and beneficial use of biosolids in an area that is seeing a dramatic increase in the number of wastewater treatment plants and an associated increase in biosolids production.

- The vegetative cover on the waste piles reduces wind and water erosion of metal-rich dusts and the associated medical risks from inhalation and ingestion.

- This approach decreases erosion and run-off contamination of surface waters.

- Provides improved aesthetics for the communities surrounding these waste piles.

Demonstration or operational projects involving similar approaches to in-situ remediation of contaminated smelter and mine wastes have been established at a number of locations in the U.S., including Superfund sites near Palmerton, PA; Kellogg/Coeur d'Alene (Bunker Hill), ID; Leadville, CO; and Joplin, MO. For more information on several of these sites visit the "Recent Research" listings posted on the web site prepared by Dr. C. L. Henry and S. L. Brown at the University of Washington at http://faculty.washington.edu/clh.

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